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ABSTRACT

This booklet is designed to aid in identifying some of the organisms that live along the Texas Gulf Coast. Also emphasized are physical and biological features of the area and proper management of commercially valuable species. Activity suggestions are included. (Author/BW)

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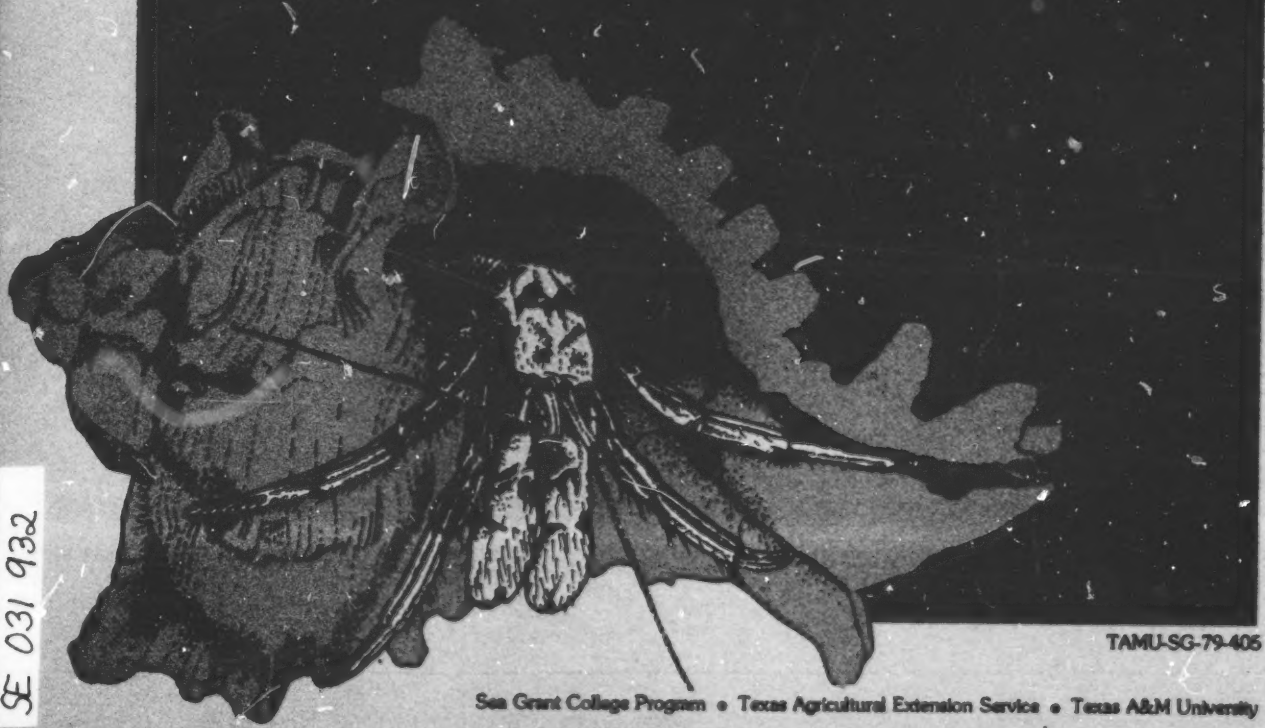

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AQUATIC SCIENCE
MARINE FISHERIES BIOLOGY

James T. Davis and Deborah J. Lightfoot*

The Gulf of Mexico is a vast ocean basin almost surrounded by the United States and Mexico. It is 800 miles long north to south, 1,100 miles wide and it covers nearly 700,000 square miles. Although it is an arm of the Atlantic Ocean, the Gulf is connected to the Atlantic only by the Straits of Florida, the Yucatan Channel and the Caribbean Sea. *See Figure 1.*

Some of the world's most valuable fisheries are found along the 3,000-mile coastline of the Gulf of Mexico. Millions of pounds of shrimp, crabs, oysters, menhaden, redfish, sea trout, black drum, red snapper and flounder are caught each year along the Gulf Coast.

The Texas Gulf Coast

Approximately 150 million pounds of fish and shellfish are landed annually on the Texas Coast, a 380-mile stretch of sandy shores and salt marshes reaching from Sabine Lake to Brownsville. The Texas coastline is marked by a series of narrow sand bars enclosing shallow lagoons. The largest of the sand bars, Padre Island, is about 100 miles long. The shoreline also has many large indentations or recesses, which form important natural harbors such as Galveston and Matagorda Bays. *See Figure 2.*

The Texas Coast supports a fascinating variety of plants and animals adapted to a demanding and constantly changing environment. This booklet is designed to help you to identify some of the organisms that live along the Texas Gulf Coast, to learn about the physical and biological features of the area, and to understand the proper management of commercially valuable species. The suggested activities are intended to guide you in your explorations and to give you ideas for designing projects suited to your specific interests.

*Extension fisheries specialist and Extension student worker, The Texas A&M University System

Figure 1. Gulf of Mexico

Figure 2. Texas Gulf Coast

LEVEL I.
BAYS, SHORES AND ESTUARIES

Coastlines are places of never-ending activity. They are subjected to continually moving water in the form of **waves, tides** and **currents.**

Waves

Waves are caused by wind. (You can make miniature waves by blowing across water in a pan. Experiment carefully with an electric fan equipped with different speeds.) The farther wind blows across water, the larger the waves. Wind speed affects wave height less than the distance over which the wind blows.

Waves move through water; they do not carry it along. Watch a buoy or other object floating on the water several hundred yards from shore. It stays in one place, bobbing up and down as waves move beneath it. *See Figure 3.* Observe a field of wheat or other tall grass. Wind creates waves that move through the grass but carry it nowhere. A wave is a form of energy that can travel through solids, liquids, gases and even the vacuum of outer space.

Figure 3. Wave movement

Waves reach below the surface, but their strength decreases with depth so little interaction occurs between them and the sea floor. As they move into shallow water near the shore, however, they are compressed by the bottom, which causes them to rise, tip forward in an arc and break. *See Figure 4.*

Breakers rush up the beach, expending the energy they gained from the wind blowing over hundreds or thousands of miles of open ocean. Breakers pound the shore in some parts of the world with a force of 25 tons per square inch. The coastline is constantly reshaped and the sand rearranged by the water racing up the beach and washing back into the sea.

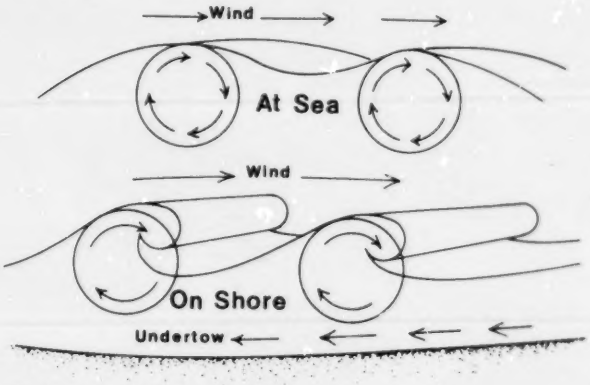


Figure 4. Wave movement

Tides

Tides are caused by the gravitational pull of the moon and the sun. These gravitational forces cause the water in the oceans to form massive bulges on both sides of the earth. As the moon revolves around the earth and the earth rotates on its axis, the tidal bulges move around the earth. The water level alternately rises and falls along coastlines, completing the cycle twice each day in most places. The Gulf of Mexico has 1- to 2-foot tides; other coasts have tides of 4 to 8 feet, or even as much as 30 to 40 feet in funnel-shaped bays like the Bay of Fundy in Canada.

When the sun and the moon lie in a direct line with the earth at full moon and new moon (see Figure 5a), their combined gravitational pull causes high tides to be very high and low tides to be very low. These are called **spring tides.** At first quarter and last quarter, when the sun and moon pull at right angles (see Figure 5b), tides are less extreme than usual. These are known as **neap tides.**

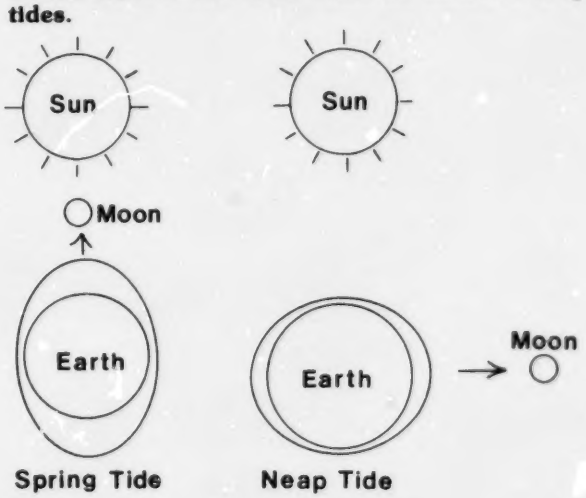


Figure 5. Tides

Currents

Surface circulation is caused by wind patterns that sweep across the earth in different latitude zones. The general pattern of surface currents is modified by physical factors and the effects of friction, gravity, the sun's heat, the general shape of land masses, local winds and the earth's rotation. Several factors may interact to complicate the general flow. For example, the earth's rotation helps form huge circular water masses that move clockwise in the Northern Hemisphere and counterclockwise in the Southern Hemisphere. As the sun heats the ocean surface in the tropics, the warmed water tends to flow toward the poles to displace colder, heavier water that in turn flows toward the equator in subsurface currents.

Currents may also be set up by wave action along the shore, creating undertows as water rushes back into the sea from the beach. Some coastal currents start with a river. Dangerous, turbulent currents known as **rips** may form where rivers meet the sea. From a high point overlooking the mouth of a bay, you may see streaks of colored water where a river flows into the sea, carrying suspended particles or sediment from the land.

Shoreline Organisms

The constant pounding of waves and the alternating exposure by tides to first air and then salt water would seem to make shorelines difficult places for organisms to live. Yet an amazing variety of plants and animals have made the coast their home. They have adapted to life on the shore in various ways. Sandy shores like those of the Texas Coast usually appear lifeless at first glance because most beach animals survive by burrowing. With few rocks or plants available on beaches for cover, most animals can live only by digging into the sand. Many clams, snails and crabs living in sand are streamlined for rapid digging to avoid injury from strong waves. *See Figure 6.*

Many sand animals depend on highly developed methods of sensing water movements to help them follow or escape water. Animals that live deep in sand avoid suffocation by blocking their gill openings to keep out sand, and by pumping water across their gills or expanding their gill area to get more oxygen.

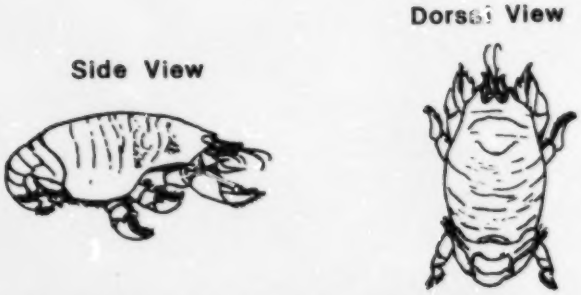


Figure 6. Sand crab *(Emerita portoricensis)*

Many organisms, including most beach plants, are so tiny they live between sand grains. These microscopic plants and animals swim or crawl through the water film surrounding grains of sand. The sand protects them from extreme changes in temperature and salt content, thus providing them with more stable conditions. Among the common organisms that live between sand grains are diatoms, dinoflagellates, roundworms, segmented worms, small crustaceans called copepods, and protozoans, relatives of the familiar freshwater amoeba and paramecium. *See Figure 7.*

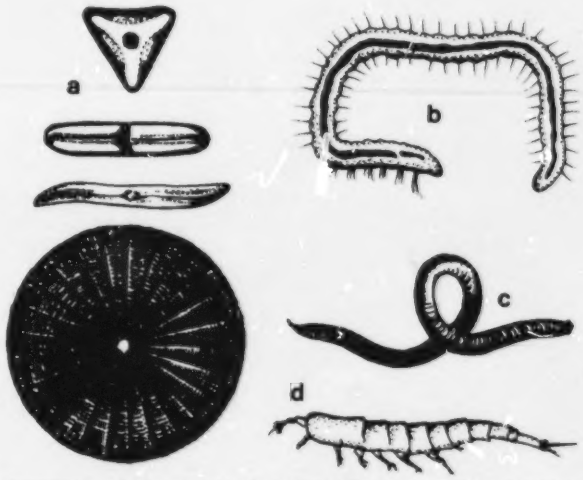


Figure 7. Organisms that live between sand grains: a. diatoms. b. segmented worm. c. roundworm. d. copepod.

Activity I. Life on the Beach

1. Observe and identify plants and animals at the beach. Watch carefully for details in form and behavior. Keep notes and records of your observations. Include information about location, date, time and weather conditions, plus a brief description of the appearance and behavior of the organisms you see. Carry a small spiral notebook and pencil with you to record your observations.

Try to find representatives of each of these groups of common seashore organisms:

- **Algae** — seaweeds, such as mermaid's hair, sponge seaweed, sea lettuce, sargassum and peacock tail.
- **Flowering plants** — plants with roots, stems and leaves including sea oats, morning glory, yaupon, sandbur, rushes and reeds, bayberry or wax myrtle, palmettos and mangrove.
- **Sponges** — simple multi-celled animals, including vase sponges and grass sponges.
- **Coelenterates** — soft, cup-like animals with tentacles and stinging cells. This group includes jellyfishes, sea anemones and corals.

- **Comb jellies** — although similar to jellyfish, they lack stinging cells and typically have only one pair of tentacles.
- **Worms** — including flatworms, roundworms and nematodes, and segmented worms such as sandworms, lugworms and parchment worms.
- **Bryzoans** — tiny animals that live in colonies; may be jellylike or encased in horny or limy sheaths. Some live in upright branching colonies often mistaken for seaweeds.
- **Echinoderms** — animals with star-like bodies covered with limy plates and sometimes spines. This group includes starfish, sea urchins and sand dollars.
- **Crustaceans** — jointed-legged animals with external skeletons. Crustaceans range in size from microscopic forms such as copepods, isopods and amphipods to lobsters and crabs weighing several pounds and having leg spans of five feet or more. Barnacles and shrimps are other important members of this group.
- **Molluscs** — soft-bodied animals, most with shells. This large group includes chitons, clams, scallops, oysters, cockles, shipworms, moon shells, slipper or boat shells, conch and helmet shells, oyster drills, whelks, mud snails, tusk shells, squids and octopuses.
- **Vertebrates** — animals with backbones, including fish, amphibians, reptiles, birds and mammals.

2. Look for tracks and burrows in the sand. Most familiar tracks left on beaches are left by birds foraging in wet sand below the high tide mark. Look for the broad, triangular marks left by gulls and the delicate, three-pronged footprints of sandpipers and other wading birds. Follow bird tracks to discover what birds eat. You may find the remains of a dead fish or a deep, narrow hole where a bird pulled a crab or worm from the sand.

Insects, small mammals and crustaceans also leave tracks on beaches. Tiny paths resembling zippers are left by scavenger beetles. Small dents in the sand may be marks left by beach hoppers or sand fleas. *See Figure 8.* Large straight paths with many sharp toe prints are made by ghost crabs. *See Figure 9.*

Follow a ghost crab's path and look for its burrow, a deep round hole in the sand. Animal burrows may be

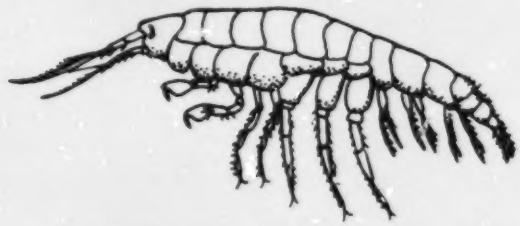


Figure 8. Beach hopper

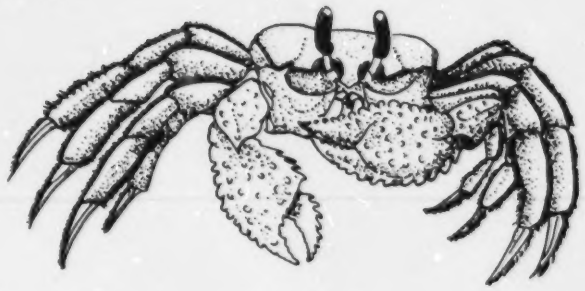


Figure 9. Ghost crab *(Ocypode albicans)*

marked by piles of sand around the hole, or they may be elevated cones or sunken conical holes. Study the hole carefully and then try to dig the animal out. At first you probably will not have much success because many burrowing animals live in long tubes that reach deep into the sand, and others can burrow about as fast as you can shovel. After a little practice you will become familiar with the design of their burrows and their methods of escape. Learn to associate animals with the outward appearance of the burrows they dig.

3. Pour samples of sand through a sieve to catch beach animals that do not build burrows but simply bury themselves in sand. Use an ordinary kitchen strainer or build a sieve from a wooden box with plastic window screening to replace the bottom.

4. Strain samples of wet beach sand through a fine net and use a microscope to look for tiny organisms that live in water between sand grains.

5. Keep a list of animals found on the beach, from below the low tide mark up to the upper beach and sand dune areas. Construct a zonation chart to show what animals live in each area of the beach. *See Figure 10.*

6. Visit the shore at night. Birds, except for an occasional owl, are absent from the beach at night; but skunks, rats, mink, raccoons and other small mammals often come to the water's edge to search for food after sundown. Shrimp and other small crustaceans that live in shallow water come much closer to shore at night. Many fishes, including killifish, sculpins, anchovies, silversides, needle fish and skates, also move closer to shore at night to feed.

Take a good flashlight or a light that fastens around your head by a band and runs on batteries that hang from your belt. Wear rough-soled sneakers and old clothes. Take a plastic bucket and a small aquarium-type net. Use an underwater flashlight to observe animals in shallow water that are not visible from the surface.

7. Collect mollusc shells and other sea shells. Molluscs are one of the oldest and largest groups of sea animals, and one of the most important. They provide food for humans, fish and other sea residents. Buttons, combs and ornaments can be made from their shells.

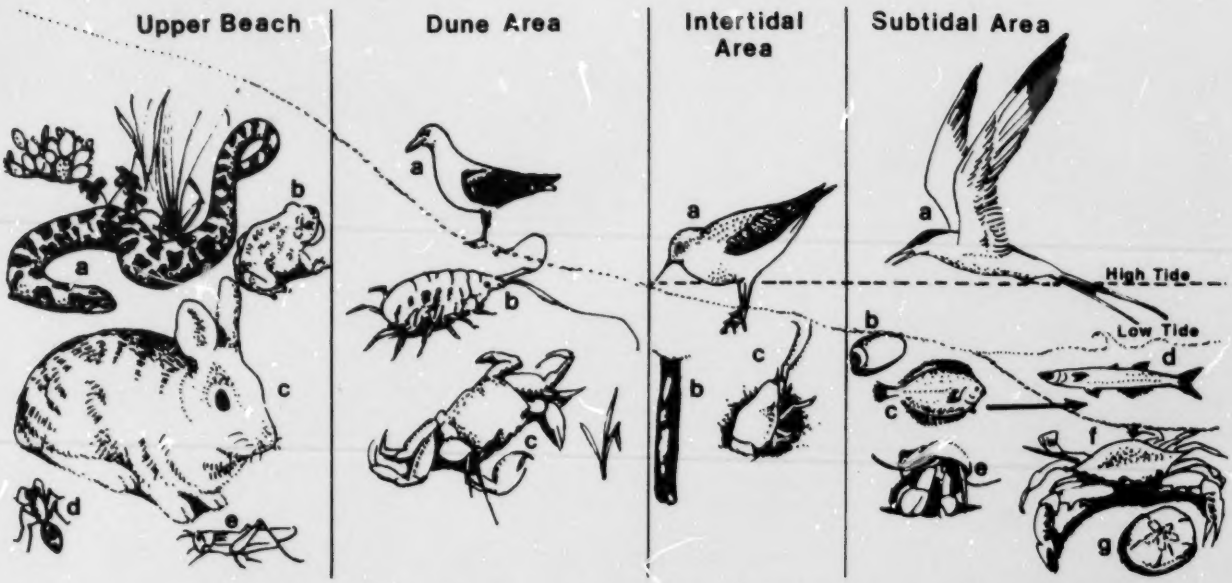


Figure 10. Beach zonation — Upper Beach: a. hognose snake; b. toad; c. cottontail rabbit; d. ant; e. locust. Dune Area: a. herring gull; b. beach hopper; c. ghost crab. Intertidal Area: a. sandpiper; b. ghost shrimp; c. sand crab. Subtidal Area: a. common tern; b. oliveshell snail; c. flounder; d. silversides; e. hermit crab; f. blue crab; g. sand dollar.

There are five kinds of molluscs:

- **Bivalves** (clams, oysters, scallops, etc.)
- **Gastropods** (snails, conches, oyster drills, whelks, etc.)
- **Chitons**
- **Tusk shells**
- **Cephalopods** (squids and octopuses)

Cephalopods are the only molluscs whose soft bodies are not protected by shells. *See Figure 11.*

Another shell commonly found on beaches is that of the sand dollar. Sand dollars are not molluscs but belong to the echinoderm group.

Determine the best times and places to look for shells. Carry a small notebook and pencil with you to record the place, date and time of your finds. Identify shells and note whether the animals were alive or dead when found. Number your shells, using India ink, to correspond with the notebook pages on which you recorded information about them.

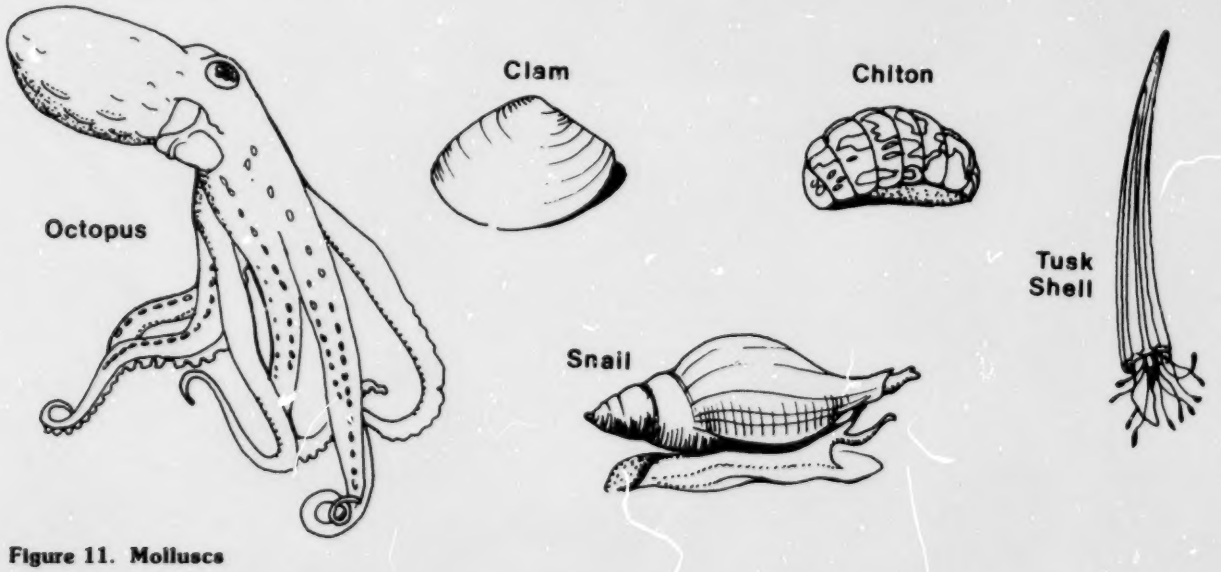


Figure 11. Molluscs

Shells can be cleaned by boiling, freezing, soaking in alcohol or diluted laundry bleach, or by hanging them in the sun to dry. Apply glycerin or mineral oil to the hinges of bivalves to keep them flexible. Display your collection in wood or cardboard cases with separate compartments (*see Figure 12*), in egg cartons, or glued to display boards. Label displays with the names of the shells, the dates and locations of collection, and the collector's name.

Estuaries

Estuaries are places on the coast where fresh and salt waters mix. They usually are drowned river valleys where sea water is diluted with fresh water flowing from a river. They also may be formed by offshore sand bars that partially isolate shallow areas of water next to the mainland.

The Texas coastline from Sabine Lake south through Corpus Christi Bay has many large estuaries where river water mixes with sea water. The lower coast lies along a narrow lagoon or bar-built estuary called the Laguna Madre.

The mixture of salt and fresh water in estuaries provides a plentiful supply of food that supports abundant plant and animal life. Tons of nutrient-rich materials washed from the uplands accumulate to make estuaries among the most productive natural systems known.

Salinity

Most estuaries undergo a gradual shift from fresh water at the river end to salt water at the ocean end. The salinity (salt content) of estuarine water may range from zero at the river end to 30 to 35 parts per thousand at the ocean end. *See Figure 13.* (**Salinity** is the amount of inorganic matter such as sodium, magnesium, calcium, potassium and chlorine dissolved in sea water. It is expressed as grams per kilogram or parts per thousand of sea water.)

Salinity in bar-built estuaries or lagoons, where fresh water is not added by a river, is determined by runoff from land, amount of rainfall and rate of evaporation. The difference between the amount of fresh water added through runoff and rainfall and that removed by evaporation determines whether the estuary is positive, negative or neutral.

In a **positive estuary,** more fresh water enters than evaporates; in a **negative estuary,** more fresh water evaporates than enters; and in a **neutral estuary,** evaporation and fresh water addition are about equal. Laguna Madre is an example of a negative estuary. It lies in a semi-arid region along the southern Texas Coast where evaporation rates are high, and salinities of more than 100 parts per thousand have been recorded.

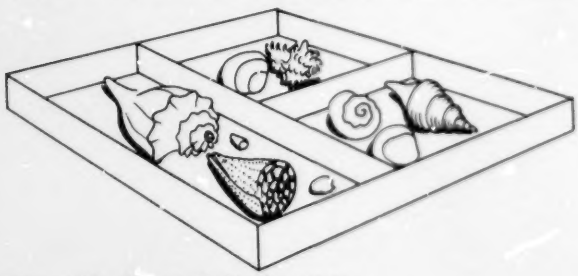


Figure 12. Seashell display case

Estuarine Zones

Estuaries are usually associated with mud flats and salt marshes covered with tall grass. The estuary and its shoreline, bottom, mud flats, salt marshes, river mouth, plants and animals make up an **estuarine zone.** Most marine life is directly or indirectly dependent on estuarine zones. It is estimated that 90 percent of all Gulf species of fish spend part of their lives in estuaries. Estuaries are important nursery grounds for fish, crustaceans and molluscs. They provide nesting, resting and feeding areas for waterfowl. Many species of amphibians, reptiles and small mammals (muskrat, mink and swamp rabbits) also live in estuarine zones. Barnacles, jellyfish, seaweeds and many other animals and plants also live in these protected, highly productive areas.

Activity II. Exploring Estuaries

1. Observe and identify animals and plants found in estuarine zones. Notice that most of the animals feed on decayed plant materials, or **detritus.** Examine their tentacles, filters, sieves, scoops, siphons and other feeding devices adapted for collecting detritus from water. Record your observations in your field notebook.

Classify organisms you observe as **nekton, plankton,** or **benthos:**

- **Nekton** are free-swimming organisms such as fishes, porpoises and some crabs.

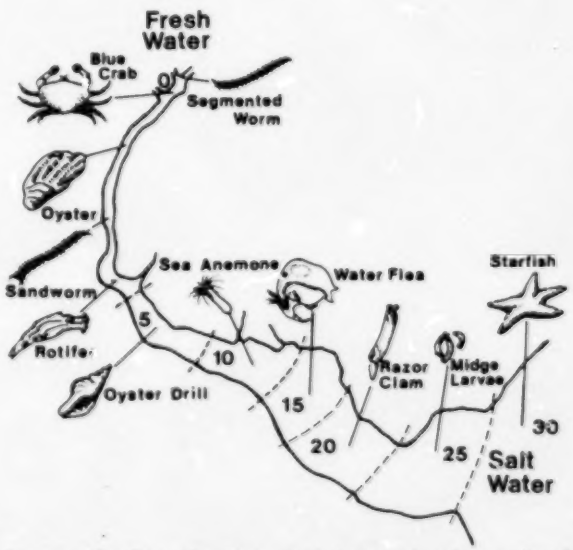


Figure 13. Distribution of typical estuarine animals based on salinity

- **Plankton** are floating organisms and weak swimmers. Most plankton are tiny plants and animals such as diatoms, protozoans and copepods; but large floating organisms like jellyfishes also are considered plankton.
- **Benthos** are organisms that live on or near the bottom. This group includes most molluscs (clams, oysters and snails), segmented worms (sandworms and parchment worms), crustaceans (crabs and shrimp), and flatfishes (flounder).

2. Determine some of the **food chains** in an estuary. A food chain is a sequence or cycle of organisms through which nutrients move. Each member of the food chain uses the member immediately below it on the chain as a food source.

The basic feeding levels that make up food chains are producers, primary consumers, secondary consumers, etc. and decomposers. Refer to *Figure 14* as you read the following paragraphs.

Producers (1) are green plants that "lock up" the sun's energy in their tissues through the process of photosynthesis (2). In the open ocean, and in bays and estuaries where the water is clear, trillions of one-celled plants called **phytoplankton** begin the food chain. (A **bay** is any partially enclosed body of water along the coast. Estuaries are types of bays.) In estuaries where the water is murky, or **turbid,** because of an abundance of suspended materials brought in by rivers and tides, sunlight will not penetrate very deep. Phytoplankton can receive adequate light only in the surface layers of water, so shore-dwelling marsh plants then become the main food source.

Primary consumers (3) are animals that eat plants. They are also called **herbivores.** Tiny sea animals called **zooplankton** are primary consumers of phytoplankton.

Secondary consumers are animals such as shrimp (4) and small fish (5) that eat zooplankton. They are also called **carnivores.** Carnivores may eat other carnivores as well as herbivores. They are then called **secondary** or **tertiary carnivores.** For example, a small fish that eats zooplankton is a secondary consumer and a first-level carnivore; a medium-sized fish (6) that feeds on small fish is a secondary carnivore; and large predatory fishes like sharks, groupers and barracudas are tertiary carnivores.

Decomposers are bacteria and fungi that feed on dead and decaying plants and animals (7). They decompose plant and animal tissues into dissolved chemicals (8) that fertilize estuaries and the ocean beyond, providing nutrients for the blanket of phytoplankton (1) floating offshore.

Construct diagrams showing the feeding relationships among some of the plants and animals you find in a bay or estuary. Below is an example of a simple shoreline food chain:

Phytoplankton → zooplankton → mole crab → ghost crab → gull → decomposers

You will soon discover that the food chains you identify are interconnected. Most animals eat many different things and, in turn, provide food for a variety of other creatures. Try to arrange food chains into a **food web** *(see Figure 15)* to give a more complete picture of the complex interactions among plants and animals.

3. Map an estuary, noting changes in plants and animals found from the river end to the ocean end. Some estuarine organisms can live only where the salinity is nearly as great as in the open ocean, while others require relatively fresh water. You can, therefore, trace the gradual change from fresh to salt water in an estuary by observing the distribution of plants and animals.

For example, at the ocean end of an estuary you may find starfish and sea urchins, which need the full salt level of the oceans. Farther upstream their numbers will drop quickly, and disappear near the river mouth. The oyster drill, a predatory snail that attacks oysters, cannot go upstream to where the salinity is much less than 9 to

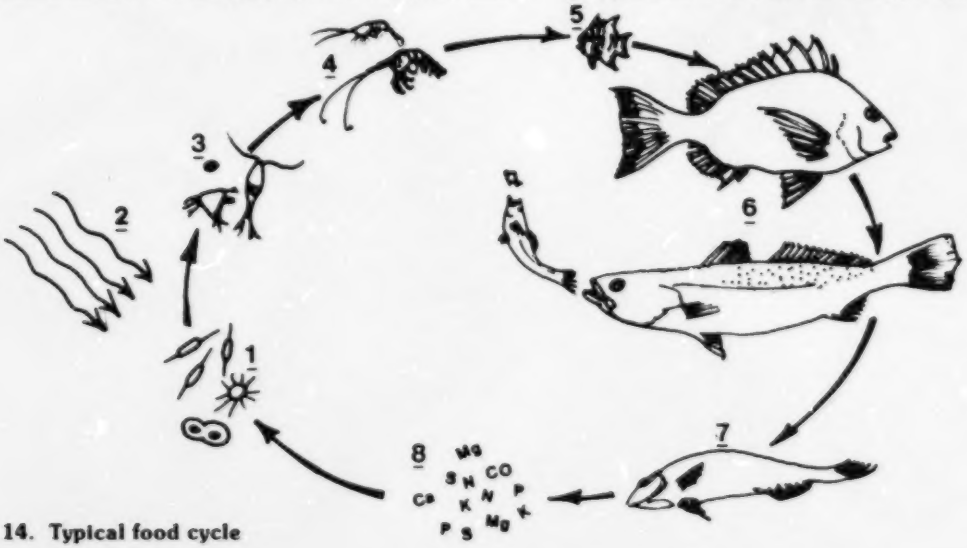


Figure 14. Typical food cycle

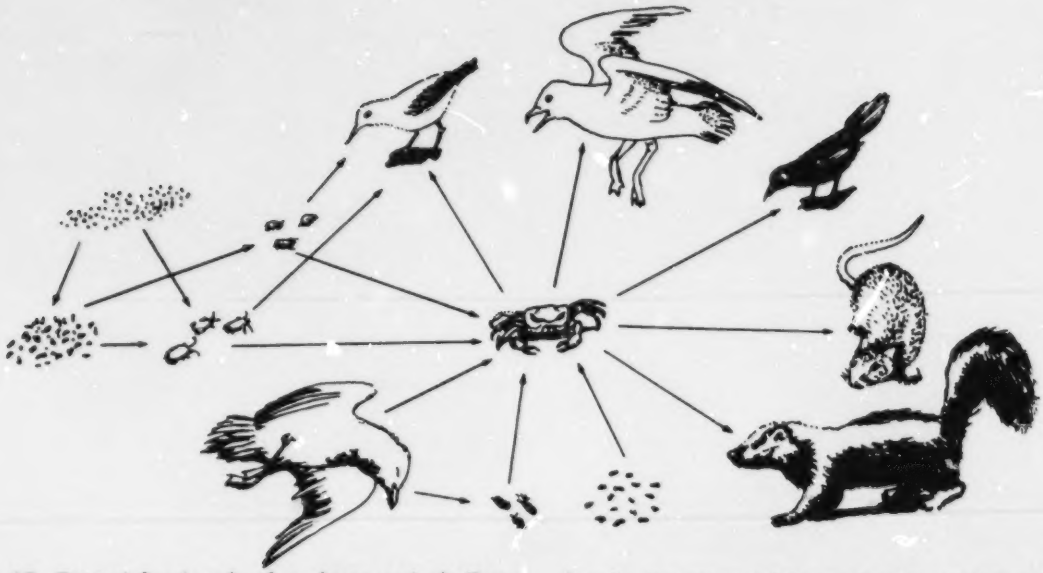


Figure 15. Partial food web of a shore and shallow water community. Ghost crab (center) feeds on dead bird, insects, isopods and amphipods, mole crabs and beach hoppers while animals such as the gull, sandpiper, grackle, rat and skunk seek out the ghost crab as part of their diets.

15 parts per thousand. Oysters can stand much lower dilutions of sea water by fresh water and so live farther upstream, safe from this predator. *See Figure 13.*

4. Look at a sample of water from an estuary under a microscope. Make sketches of the tiny plants and animals you see. Take water samples from an estuary at different seasons of the year. You will find the greatest number and varieties of organisms in spring, when "blooms" of phytoplankton occur and newly hatched animals or larvae make up a large part of the zooplankton.

In summer, populations of phytoplankton begin to decrease because of grazing by animals, a drop in available nutrients, and less light. The light in coastal waters reduces as summer approaches because the dense blanket of plankton keeps sunlight from filtering down through the water.

Animal plankton decreases in late summer and early fall because of the decrease in its food supply of phytoplankton and because many planktonic larvae have grown into larger nonplanktonic forms. Plankton populations, both plant and animal, drop to their lowest levels in winter.

5. Discuss possible damage to estuaries in your area from industries and cities that dump wastes into them as well as from dredging and filling. Estuaries are favorite sites for industries such as paper mills and chemical plants that need large supplies of water for manufacturing processes and waste disposal. Cities and watercraft also find estuarine zones convenient and economical places to dispose of sewage. Plants and animals in estuaries can change a large amount of man's waste materials into nutrients useful to marine life, but if too much waste is added to an estuary, or if it is filled, nature cannot handle the problem.

Excessive pollution can cause oysters, which are filter-feeders and concentrate wastes in their bodies, to become unsafe as human food. Pollution can make estuaries smell bad and be unfit for water sports. Enormous fish kills have occurred in estuaries because of pollution. We do not yet know all the effects pollution may have on marine life. Some substances accumulate slowly in mud, water and animals. Their effects on organisms may go unnoticed for a long time.

Garbage and solid wastes are dumped into some estuarine areas to create land fills. Channels are being dredged in some estuaries, which may change the salinity, temperature or currents so much that valuable estuarine animals cannot survive there. Such dredging and filling activities may be even more damaging to estuaries than pollution. From 1950 to 1969, Texas lost 68,100 acres, or 8.2 percent, of its estuarine habitat important to shrimp, fish and other wildlife because of dredging and filling.

LEVEL II.
FISH AND SHELLFISH IDENTIFICATION

The most important marine fisheries products of the Texas Coast are **shrimp, oysters, crabs** and **finfish.** As mentioned earlier, Texas sport and commercial fishermen land about 150 million pounds of these seafoods each year. The activities in this section are designed to help you learn to identify some species of fish and shellfish that are commercially important in Texas.

Activity I. The Shrimp Fishery in Texas

Many kinds of shrimps inhabit the shallows of the coast and deep waters of the Gulf of Mexico, but few species grow large enough to be important as human food sources. Those that do include brown shrimp, white shrimp, pink shrimp, seabob and royal red shrimp.

1. Learn the major characteristics of external shrimp anatomy by studying live or preserved specimens. Like other crustaceans, shrimp are segmented animals with outer shells. *See Figure 16.* The head spine (rostrum), walking legs (pereiopods) and feelers (antennae) are connected to the fused head and thorax region. The swimmerets (pleopods) and the tail fan (uropod) are connected to the edible "tail" or abdominal section.

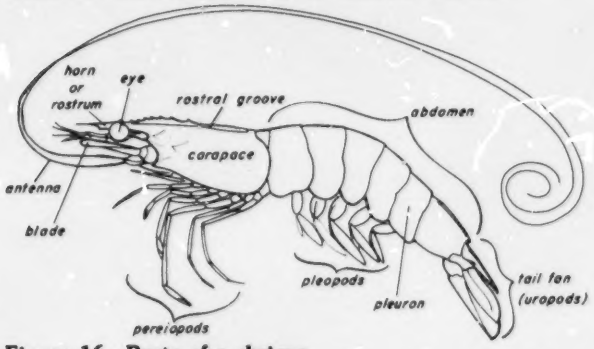


Figure 16. Parts of a shrimp

2. Learn to use a **dichotomous key** to identify shrimp and other marine animals. Dichotomous keys list two sets of identifying characteristics at each step in the key. Read both sets carefully before deciding which best matches the organisms you are trying to identify. After each set of characteristics, you will find either the name of the organisms described or a number directing you to the next step needed to complete the identification.

The following is a key to commercial marine shrimps of Texas:

(1) Teeth absent from ventral (lower) surface of head spine (rostrum) 2
(1) Teeth present on ventral surface of head spine 4

(2) Last two pairs of walking legs not greatly elongated and slender 3
(2) Last two pairs of walking legs greatly elongated and slender; head spine long and upturned ..... Seabob

(3) Head spine much shorter than head (carapace); post-orbital spine (spine behind the eye) not present ..... Broken-Necked Shrimp (*Trachypeneus* spp.)
(3) Post-orbital spine on side of head; inhabits great depths (175 fathoms) ..... Royal Red Shrimp

(4) Deep grooves present on both sides of rostral keel of head; head spine not long, feelers (antennae) less than twice the body length 5
(4) Grooves not present on head; feelers over twice the body length; head spine long; body whitish with greenish tint on last tail segment ..... White Shrimp

(5) Thumbnail will not fit into grooves on sixth tail segment; reddish spot between third and fourth tail segments; head spine tip not upturned in specimens under two inches ..... Pink Shrimp
(5) Thumbnail will fit into grooves of sixth tail segment; no reddish spot on abdomen; specimens under two inches may usually be identified by the slightly upturned rostrum tip ..... Brown Shrimp

Activity II. Oysters in Texas

Oysters are often grouped with shrimps and crabs under the term "shellfish," but they are not related to either. Oysters are bivalve molluscs, with their two shells hinged together at one end and pulled closed by a single large muscle attached near the other end.

Only one species is commercially important on the Atlantic and Gulf Coasts — the American oyster. *See Figure 17.* It can be found in all bays along the upper and middle Texas Coast. It is absent from most of the Laguna Madre but is found near Port Isabel and in South Bay.

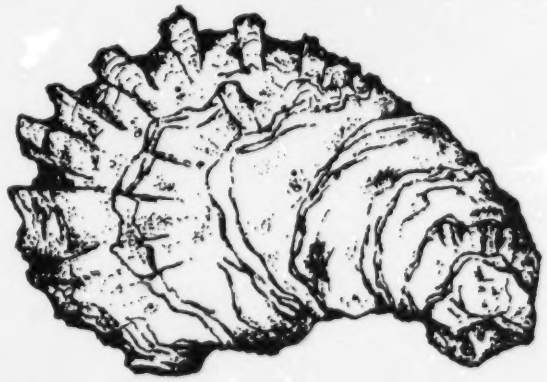


Figure 17. Oyster

1. Examine an opened oyster shell. Note that the two halves of the shell, or **valves,** are hinged in the pointed region of the two **beaks.** The valves are not exactly the same size and shape. Look for the connecting ligament between the valves near the beaks. The valves provide protection for the oyster while the ligament forces the valves apart so water containing food and oxygen can enter.

Activity III. Crabs in Texas

The crabs of the Texas Coast and its offshore waters are found in every zone from the depths of reefs and coral banks in the Gulf of Mexico to holes in beaches high above the tide mark. Crabs are the most numerous group of crustaceans. Ninety-two species have been reported in Texas, but only one, the blue crab, is harvested commercially.

1. Learn the major characteristics of external crab anatomy. The crab's soft body is completely enclosed in a hard shell called the **cephalothorax.** *See Figure 18.* Although a crab's shell seems to be all in one piece and not segmented like other crustaceans, it actually is formed from many segments fused together. The top of the shell is called the **carapace,** while the bottom or abdominal part is called the **apron**. The eyes are mounted on movable stalks and project from the front of the carapace. They can be withdrawn in times of danger. The antennae and antennules, which are sensory organs, are located between the eyes. The six pairs of mouthparts are located on the lower front side of the cephalothorax.

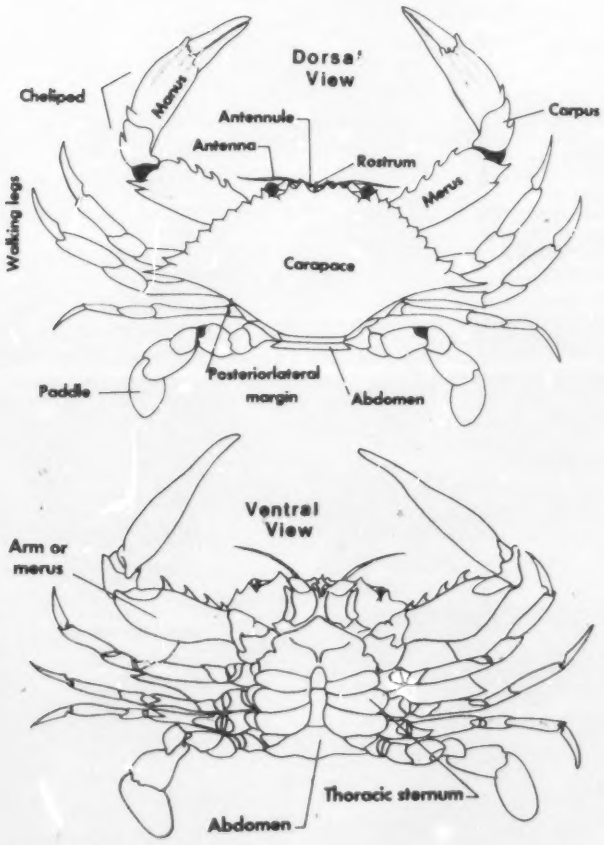


Figure 18. Parts of a crab

Crabs have five pairs of legs, the first pair bearing strong claws used for gathering food and as defense weapons, the next three pairs used for walking, and the last pair bearing the paddles for swimming. The muscles controlling the legs are anchored inside the body on the inner surface of the shell.

2. Examine and identify as many crabs as you can. Keep records in a small notebook, including the date, location and time of observation, and a description of the crab's appearance and behavior. Use a guide book or key to help you identify species. *See Table 1* for a checklist of common Texas crabs.

Table 1. Checklist of Common Texas Crabs

Mud shrimp	Mud crab
Porcelain crab	Stone crab
Sand or mole crab	Ghost crab
Hermit crab	Fiddler crab
Frog crab	Great land crab
Rock or box crab	(white land crab or
Calico crab	mullato land crab)
Blue crab	Shore crab
Gulf weed crab	Oyster crab
Speckled crab	Mussel crab
Lady crab	Long-armed crab
Purse crab	Spider crab

Activity IV. Food and Game Fishes of the Texas Coast

Texas marine fishes may be divided into three general groups, including:

- **Littoral fishes** — those which inhabit the bays and near-shore waters of the Gulf, such as trout, redfish and drum
- **Pelagic fishes** — those which live in the open waters of the Gulf, such as Spanish mackerel and sailfish
- **Reef fishes** — those which live around reefs and coral banks, including snappers, groupers and jewfishes

Fishes also may be classified according to how advanced they are in structure. The most primitive fish are **jawless fishes;** the next group includes **cartilaginous fishes;** and **bony fishes** make up the most advanced group.

Jawless fishes have no bones, jaws, paired fins or scales. Their bodies are supported by cartilage, and their mouths are round and modified for sucking. This group includes lampreys and hagfishes, most of which are marine fishes that live in temperate or cold waters and are extremely rare in Texas waters.

Cartilaginous fishes also have a skeleton of cartilage instead of bone, but it is further developed than in the jawless fishes. This group includes sharks, skates and rays. They have well-developed lower jaws, and both jaws have bony teeth. These fishes have paired fins and scales. Their scales, called **placoid scales,** are similar to teeth and entirely different from the scales of bony fishes.

Bony fishes make up more than 95 percent of all known kinds of fish. Most familiar food and game fishes, including spotted sea trout, redfish, red snapper, black drum and flounder, are bony fishes.

1. Learn the characteristics of fish anatomy that are helpful in identifying fish. *See Figure 19.* Fish are identified by the proportions of their bodies, the number of spines and rays in the fins, the location of body parts, the scale count, the teeth, the eye diameter and the internal anatomy. Color is usually not a reliable means of identification. Most fish change color rapidly while on the hook, when removed from water and at death. Some fish change colors normally while swimming in their natural habitats. The colors described below are the ones most often seen by the fisherman as he makes his catch.

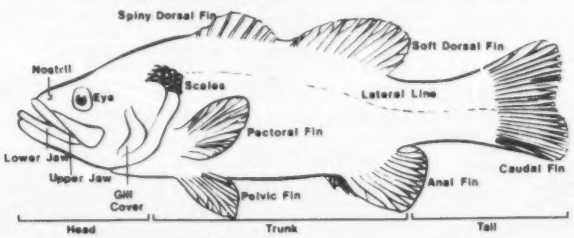


Figure 19. Parts of a fish

2. Identify as many fishes as you can. Keep records for those you name, including date, time and location of observation, and a description of appearance and behavior. *See Figure 20* for sketches of the following food and game fishes of the Texas Coast:

Atlantic Sharpnose Shark. Average length of adult is 2½ feet, maximum 3 feet. Frequents the bays and Gulf beaches, stays close to shore and is often found in river mouths. Eats fish and crustaceans. Brown or gray above, shading to white below. It can be recognized by the wrinkles at the corners of the mouth and by the teeth which slant toward the corners of the mouth. The flesh is edible.

Bull Shark. Reaches a length of 10 feet and a weight of 400 pounds. Those caught by fishermen are usually under 7 feet. Lives in shallow waters, bays and estuaries. Eats smaller fishes of all kinds. Light or dark gray above and white below. The flesh is edible and the skin is sometimes used for leather.

Blacktip Shark. Adult reaches about 6 feet in length. Travels in schools and is very active, often leaping out of the water. Eats small fishes of all kinds. Pectoral fins black-tipped in adult; all fins black-tipped in young. Color varies from blue-gray to brown-gray, darker above and lighter below. The flesh is edible and the skin is sometimes used for leather.

Hammerhead Shark. Adult may reach a length of 10 feet or more. Inhabits both deep and shallow waters. Usually swims near the surface with the dorsal fin showing. Eats fishes, squid, stingrays, crabs, other sharks (and on one known occasion a human). Brownish-gray above and pale below; tips of fins are darker. Flesh is edible and the skin is sometimes used for leather.

Bonnethead Shark. Adult occasionally reaches 4 feet but is seldom over 2 feet in length. Inhabits shallow waters. Feeds on fish, crabs, shrimp and other crustaceans. Gray on the back and paler on the underside. Flesh is edible.

Shortfin Mako Shark. Adult sometimes reaches 12 feet in length, and on the average weighs about 1,000 pounds at 10 feet of length. Found near land as well as far out in the ocean where it preys on schooling fish such as mackerel and herring. It will attack and destroy the broadbill swordfish. Deep blue-gray on the back and snow-white underneath when freshly caught. Appears dark blue in the water. Flesh is edible.

Stingray. Averages width of about 6 or 8 inches; sometimes reaches a foot in width. Southern stingray sometimes reaches a width of 5 feet. Frequents bays in summer, migrates to the Gulf in winter. Occurs in river mouths and has been known to enter fresh water. Lives on or near the bottom and feeds on bottom-dwelling worms, molluscs and crustaceans. Back is gray-brown; underside is pinkish white. Flesh is edible.

Tarpon. Occasionally reaches weights up to 350 pounds. Frequents Gulf coastline, entering bays, river mouths, harbors and can live in fresh water. Feeds on mullet, crabs, pinfish, shad, catfish. Most abundant from June to October. Brilliant silver color; scales very large. Flesh is edible but has little flavor.

Ladyfish. Adult averages 1 or 2 pounds; sometimes as much as 8 pounds. Frequents Gulf beaches, passes and inner bays. Feeds on small fish and shrimp. Brilliant silver with a slight greenish cast on the back. Flesh is edible but full of many small bones.

Gafftopsail Catfish. Average weight is 1 to 2 pounds; sometimes reaches 5 to 6 pounds. Common in bays, passes and along beaches. Swims actively in channel currents, feeding on shrimp, small crustaceans and fish. Usually feeds near the bottom. Back is light sea-green or blue, shading to nearly white below. Flesh is edible.

Sea Catfish. Weighs from ½ to 3 pounds. Feeds in schools along beaches, in harbors, bays and inlets. Most abundant in bays during the summer. Grayish or gray-green on the back, yellowish to white beneath. Flesh is edible but not usually eaten.

Southern Flounder. Adult averages from 1 to 2 pounds; has been known to reach 26 pounds. Prefers sandy or silty bottoms along the shores of bays where it can bury itself with only the eyes showing to wait for food. Eats small fishes, squid, shrimp, crabs and other small crustaceans.

Can be caught year round. Colors are mottled and vary from dark olive to light brown on the top; bottom is white. Harmonizes closely with background. Flesh is edible.

Striped Mullet. Average weight is ½ pound; maximum 5 to 6 pounds. Commonly moves in schools. Frequents beaches, harbors, river mouths and bays. Sometimes goes up rivers into fresh water for hundreds of miles. Eats plankton and tiny bits of organic matter found in mud and on the sides of submerged objects. Back dark blue to black. Scales on the sides give the appearance of dark and light stripes. Underside silverish white. Used as a food fish and for cut bait.

Great Barracuda. Average weight is 5 to 25 pounds. Usually swims alone near the surface over reefs. Eats other fish. Excellent game fish. Coloration varies from light sea-green to nearly black above. Silvery on the sides and white on the underside. Usually has irregular black spots on the sides. Flesh is edible; however, caution should be exercised since barracuda have been known to eat poisonous fish.

Wahoo. Average weight is 20 pounds. Inhabits the open ocean and Gulf Stream. Usually solitary, feeds on small fish. One of the fastest swimming fishes. Back grayish-blue, fading to lavendar on the sides and silver on the underside. Very small wahoos have pronounced vertical markings. Flesh is edible.

King Mackerel. Average weight is 10 to 15 pounds. Schools usually keep to the open ocean, but congregate in large numbers about the reefs at Galveston, Freeport and Port Arthur. Usually caught only in deep, clear water. Eats squid and scrap fish shoveled overboard from shrimp boats. Back and upper sides are bright green or blue-green. Rest of the body is silver; no markings. Flesh is edible.

Spanish Mackerel. Average weight is 2 pounds. Common on the Texas Coast from March to September. Feeds on small fish, shrimp and squid. Frequents mouths of harbors and passes, rarely going into bays. Back and upper sides blue or blue-green, shading to silver below. Rows of orange or brown spots on sides. Flesh is edible.

Atlantic Bonito. Average weight is 6 to 10 pounds; occasionally reaches 20 pounds. Found in schools in blue water offshore. Feeds on menhaden and other small fish. Dark bluish-silver above; shading to silver below, with darker stripes slanting forward from the back. Flesh is edible.

Blackfin Tuna. Average weight is 10 to 20 pounds; occasionally reaches 30 pounds or more. Lives in schools offshore; feeds on small fish. Dark blue on the back, shading to silver below. Vertical bars and rows of dots on the sides below the unusually long pectoral fins. Some have a yellow streak on the sides. Flesh is edible.

Sailfish. Average weight is 35 to 40 pounds. Usually found far offshore. Eats menhaden, shrimp, mullet and other fishes. Unusually large dorsal fin, the "sail," distinguishes the fish from all others. Dark blue with black dots in rows between the spines; sometimes folded down into a depression in the back. Pectoral, anal and tail fins and back are dark bluish-green or bluish-purple; fades to white below the lateral line. Flesh is edible; best when smoked.

Blue Marlin. Average weight is 200 pounds; known to reach 1,500 pounds. Generally found far offshore in blue water in July and August. Usually a solitary fish; eats small fishes. Similar in color and appearance to the sailfish but large dorsal fin is absent. When excited, rows of vertical lavendar stripes appear on the sides. Flesh is edible; best when smoked.

White Marlin. Ranges from 50 to 100 pounds. Found both singly and in schools in blue water where it feeds on schools of small fish and on squid. Similar to blue marlin in both color and form, but tips of the first dorsal and anal fins are rounded rather than pointed; the dorsal fin has dark spots and the lateral line is very conspicuous. Flesh is edible; best when smoked.

Dorado. Average weight is 5 to 6 pounds. Follows driftwood or patches of seaweed. Seldom found alone or in pairs; lives in schools. Eats small fishes such as mullet and flying fish. Coloration varies, changing rapidly when the fish is excited. Usual color when hooked is dark blue on back and dorsal fin (dark green in females), shading to gold below. Other fins gold. Small purple dots on the body and dorsal fin. Flesh is edible.

Crevalle Jack. Average weight is 2 to 5 pounds; occasionally reaches 40 pounds. Small jacks run in schools in bays; may be found around bridges, pilings and other structures. Adults run offshore around mouths of passes and rivers. Eats mullet, other small fish and crabs. Back greenish, sides white, underside yellowish. Upper fins dark, lower fins yellow. Black spot at the upper edge of the gill cover and another at the base of the pectoral fin. Flesh is edible.

Florida Pompano. Average weight is 2 to 5 pounds. Common around passes and in the surf; feeds on molluscs, crustaceans, beach fleas, shrimp and small fish. Back grayish-blue, shading to silver on the sides, yellow beneath. Upper fins dark, lower ones yellow. Bluish tint above and in front of the eyes. Flesh edible and delicious.

Bluefish. Average weight is 1 to 2 pounds; known to reach 25 pounds. Travels in dense schools and is migratory. Eats small fish, squid and shrimp. Generally found offshore, associated with schools of small dorados. Dark greenish-blue on back, shades off to bluish-silver on sides. Underside silver. Pectoral fins blackish at base. Flesh is edible.

Cobia. Average weight is 15 to 30 pounds. Found around buoys, under floating debris, around large fish and under turtles. Young vividly striped in black and white, common during May, June and July in harbors and around docks. Feeds on small fish, squid, crabs and shrimp. Dark brown on back, silvery white below. Dark lateral band about the width of the eye extends from snout to tail. Below this is a narrower band. Fins are dark. Flesh is edible.

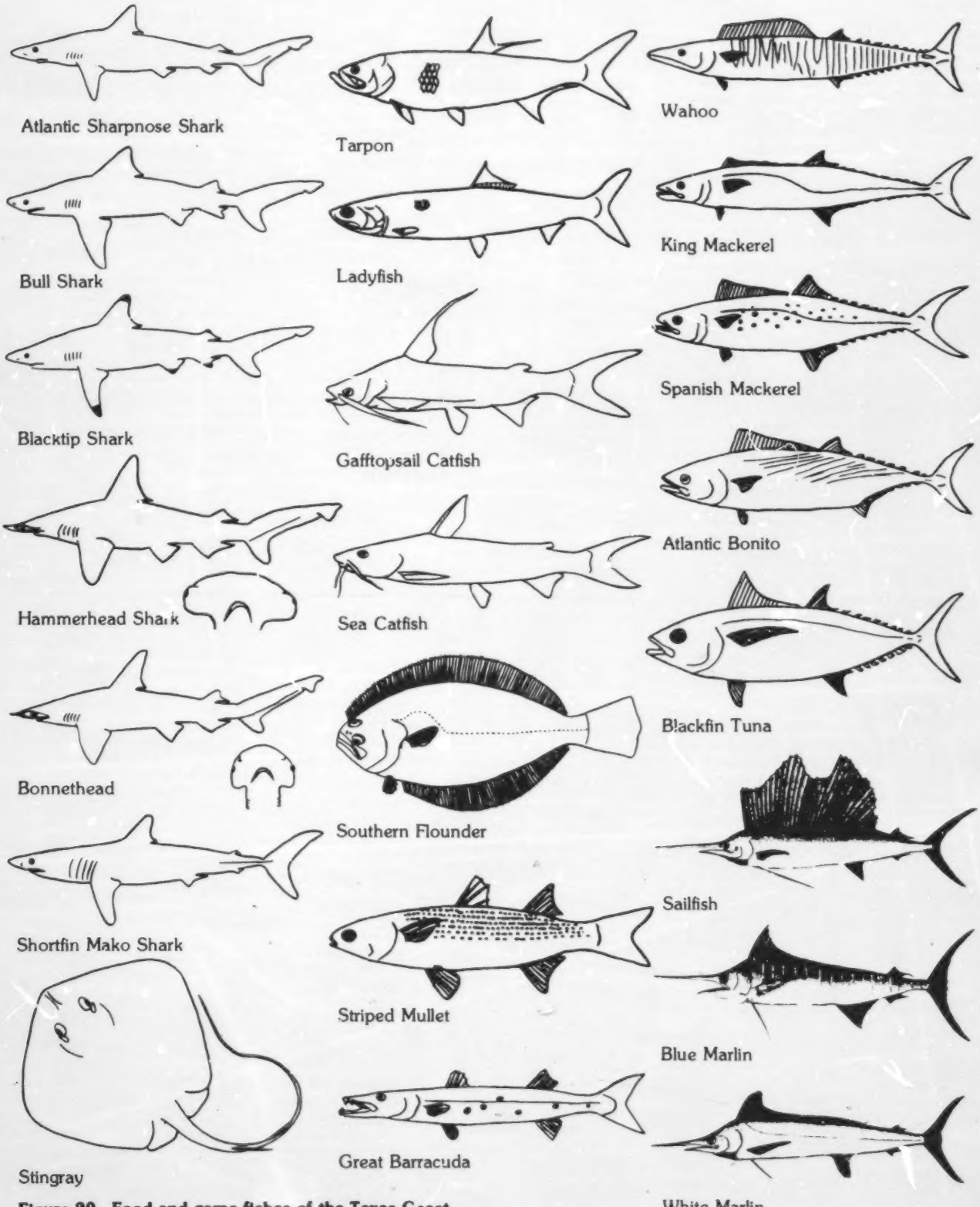
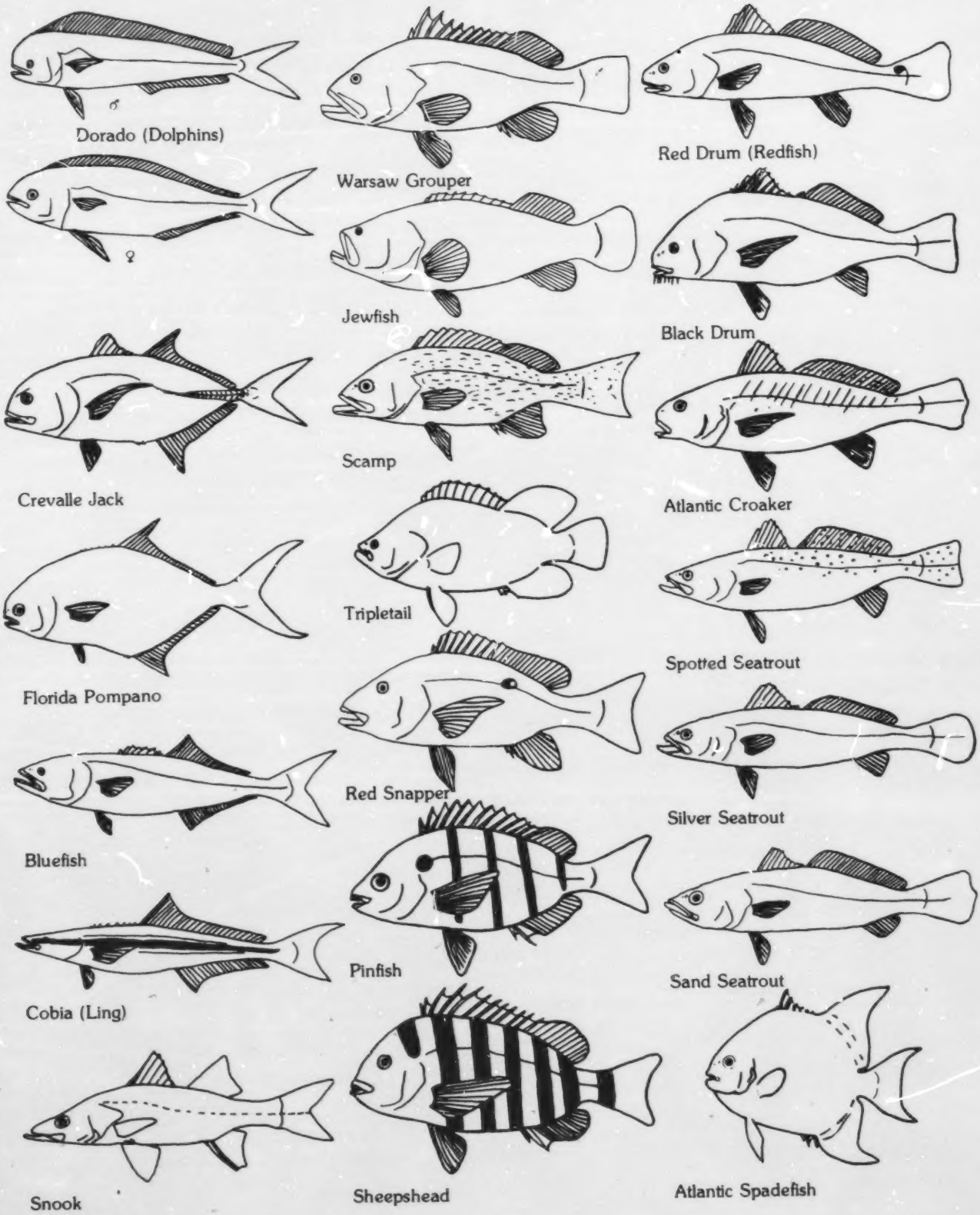


Figure 20. Food and game fishes of the Texas Coast


Dorado (Dolphins)
Warsaw Grouper
Red Drum (Redfish)
Jewfish
Black Drum
Scamp
Crevalle Jack
Atlantic Croaker
Tripletail
Florida Pompano
Spotted Seatrout
Red Snapper
Silver Seatrout
Bluefish
Pinfish
Sand Seatrout
Cobia (Ling)
Snook
Sheepshead
Atlantic Spadefish

Snook. Usually weighs less than 25 pounds. Frequents passes, inlets, cuts and mouths of creeks and rivers; sometimes goes up rivers to fresh water. Feeds on smaller fishes, crabs, freshwater crawfish and shrimp. Brackish water snooks are brownish on back, tan below. Saltwater snooks are tan on back and silvery below. Lateral line very dark. Flesh is edible.

Warsaw Grouper. Weighs from 20 to 60 pounds; can weigh 100 pounds or more. Generally found only on snapper banks when large; small ones often found in bays near channels. Eats crabs. Brown or bluish-black, some have a few light spots. Flesh is edible.

Jewfish. Average weight is 40 to 120 pounds; often reaching 200 to 300 pounds or more. Generally found around jetties, pilings, old wrecks, inshore coral reefs and in entrances to creeks and sloughs. Eats almost anything it can catch. Colors range from dark to chocolate brown. Some have faint pale blotches. Fins are dark. Young are mottled and have small black spots; adults lose these markings. Flesh is edible.

Scamp. Reaches a length of 24 to 30 inches and weight of 8 to 10 pounds. Occurs on snapper banks during most of the year. Brown above, grayish brown on the sides and sometimes covered with darker spots. Vertical fins dusky with outer portions bluish-black. Pelvic and pectoral fins have a narrow band of white. Flesh is edible.

Tripletail. Average weight is 5 to 15 pounds. Prefers mouths of rivers, passes and bays opening into the Gulf. Congregates around shipwrecks, buoys, boats, beacons, pilings, flotsam, rock jetties and, in some cases, close to shore under the shelter of fallen trees and brush. Often floats on its side just under the surface. Eats small fishes, crabs and shellfish. Adults usually black; young change colors, may be mottled yellow and brown or a solid yellowish tan. Flesh is edible.

Red Snapper. Average weight is 2 to 4 pounds. This is a reef fish but small ones are frequently found miles from any known reef. Eats small fish, crabs, shrimp and squid. Deep rosy red color. Flesh is edible.

Pinfish. Average length is 6 to 8 inches, sometimes reaching 14 inches. Frequents grassy bays in warm weather, migrates to deeper water in colder months. Eats vegetation, small crustaceans and molluscs. Horizontally striped with blue and yellow and may be vertically barred with light brown. Fins gray and yellow. Usually a dark spot above the gill cover. Flesh is edible; commonly used for live bait.

Sheepshead. Averages 1 to 3 pounds but occasionally reaches 25 pounds. Frequents pilings, jetties and oyster reefs and sometimes goes up rivers to fresh water. Feeds on barnacles and small shellfish. Vividly marked with black and white vertical bars. Flesh is edible.

Redfish. Averages 3 to 4 pounds, occasionally reaches 85 pounds. Travels in schools; young frequent bays and adults frequent passes and channels between bars. Feeds on shrimp, crabs, small fish including mullet and pinfish. Color ranges from silver to copper. Scales are silver around the edges and usually coppery in the center. Fins are grayish silver. Black spot present at upper base of the tail. Flesh is edible.

Black Drum. Average weight is 3 to 4 pounds, occasionally reaching 40 pounds. Frequents shallow bays; feeds on shellfish, shrimp, crabs and an occasional fish. Color ranges from smoky black to silver gray, with four or five darker vertical bars. Bars disappear with age. Fins are dark. Flesh is edible.

Atlantic Croaker. Average weight is ¼ to ½ pound, but may reach 2 to 3 pounds. Frequents bays and Gulf beaches, feeding on crustaceans, molluscs, and small fishes. Brassy silver above, paling to whitish-silver below. Faint, irregular dusky bars cross the lateral line. Tiny barbels present on underside of the lower jaw. Flesh is edible.

Spotted Seatrout. Also known as speckled trout. Averages 15 inches in length and 1 to 2 pounds in weight. Found in bays and along beaches. Prefers grassy areas where it feeds on shrimp and small fish. Back dark bluish- or grayish-silver, shading to whitish-silver below. Many small, round black spots occur above the lateral line on the body, dorsal fins and tail. Flesh is edible.

Silver Seatrout. Rarely exceeds 2 pounds. Common along beaches. Eats shrimp, other invertebrates and small fish. Pale greenish- or bluish-silver on the back, shading to silver on the sides and below. Flesh is edible.

Sand Seatrout. Rarely exceeds 1 pound. Common in bays and migrates to the Gulf only in cold weather. Feeds on smaller fishes and crustaceans, and is most abundant in the bays in late summer and fall. Often confused with the silver sea trout, but this fish has 11 rays in the anal fin whereas the silver sea trout has 8 or 9. Entire body is silver, a little darker on the back than on the underside. Flesh is edible.

Atlantic Spadefish. Also known as angel fish. Rarely exceeds 1 pound in Texas waters. Generally found in schools around jetties, wrecks, pilings and bridges. Prefers shrimp. Usually vertically barred with black and silver, but is sometimes completely black, gray or white. Flesh is edible.

Another very important marine fish in Texas, although not a food or game fish, is the **menhaden.** *See Figure 21.* Menhaden are small fish used for meal and oil. Menhaden meal has a high protein content and is used extensively in livestock feeds. The menhaden industry is Texas' third most valuable fishery, surpassed only by shrimp and oysters.

Consult a key or guide book for more detailed descriptions of these and other Texas marine fishes.

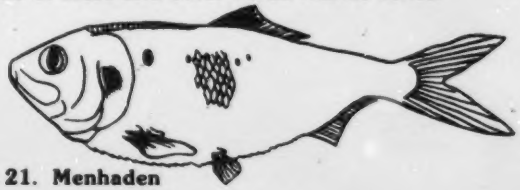


Figure 21. Menhaden

LEVEL III.
LIFE HISTORY AND MANAGEMENT

Mankind has depended on the sea for food throughout history. Our ancestors harvested oysters, shrimp, crabs, lobsters, sea trout, flounder and other succulent seafoods, enjoying a seemingly inexhaustible food supply. As the human population grows and land becomes increasingly scarce, the sea must be made to supply even greater amounts of high-quality protein foods.

In order to improve fish harvests, biologists study the spawning, feeding, growth and migration of fish and shellfish. They use the information obtained to develop proper management techniques and protective laws. For example, the Texas menhaden fishery, which has yielded a catch of as much as 99 million pounds in one year, was established only after research showed it would not have a detrimental effect on other fisheries.

The activities suggested in this section are designed to help you learn about the life histories of commercially important marine animals and how they are harvested and processed as food.

Activity I. Life History Studies

1. Choose one or more commercially important species of shrimp, oysters, crabs or finfish. Find out all you can about the species you choose by talking to fishermen, reading books and encyclopedias and observing animals directly. Write a report about the species chosen and include information on:

- Classification (kingdom, phylum, class, order, family, genus and species). For example the blue crab would be classified as follows:
  - Kingdom .....Animalia (animals)
  - Phylum .....Arthropoda (arthropods)
  - Class .....Crustacea (crustaceans)
  - Order .....Decapoda (decapods — crabs, lobsters, crawfish, shrimp)
  - Family .....Portunidae (swimming crabs)
  - Genus .....*Callinectes*
  - Species .....*sapidus*
- All common names used for the species in Texas and the United States
- Description and identification characteristics
- Habitat requirements (temperature, salinity, water depth, etc.)
- Food and feeding habits
- Spawning habits
- Range (waters where it is found)
- Migration, if any
- Natural enemies (predators and parasites)
- Importance to man

2. Ask everyone in your 4-H club to write about different species. Make copies of their papers for each club member or ask them to report to the club on the animals they studied.

Activity II. Seafoods harvesting

1. Find out when fish and shellfish are caught. Most seafood crops experience a season of peak harvest, although some are harvested year round. Major shrimp harvests, for example, occur from July to October. This period corresponds to the time most brown shrimp leave the estuaries as sub-adults and return to the Gulf to mature and spawn. However, several tons of shrimp are landed each month throughout the year. Crabs are also harvested year round although their peak harvest period is from May to November. Oysters are harvested mainly during the fall and winter months. This is largely due to legal restrictions on the harvest of commercial oysters from public reefs.

2. Find out where fish and shellfish are caught. Some species are caught only in the open waters of the Gulf, while others may be taken only in protected bays and lagoons. For example, most of the shrimp and all of the menhaden and red snapper landed in Texas are caught in the Gulf. Oysters are not harvested from the Gulf, however. Most oysters and blue crabs are taken from Galveston and Trinity Bays. Most finfish are caught in the Gulf and in Laguna Madre.

3. Find out how seafoods are harvested. For example, most shrimp are caught with trawls. These are cone-shaped nets that taper to a narrow end and are towed behind shrimp boats. Although many crabs are taken in shrimping operations, most are caught in traps or pots. Traps are made from a metal frame in the shape of a box covered on all sides by ½-inch chicken wire. Holes about 4 inches in diameter are cut in two or four of the sides. Funnels of hardware cloth are inserted into the holes so that the small openings project into the trap, which is baited with meat scraps or dead fish.

Talk to commercial and sport fishermen and read reports issued by the Texas Parks and Wildlife Department and the National Marine Fisheries Service for more detailed information about harvesting seafoods. Invite a fisheries biologist to speak to your club about the Coastal Fisheries Program in Texas. Ask about the marine studies conducted by the department and how the results are used to develop proper management techniques. Write to the Texas Parks and Wildlife Department, 4200 Smith School Road, Austin, Texas 78744, and the Sea Grant College Program, Texas A&M University, College Station, Texas 77843, for assistance or publications they may have containing information about the coastal fisheries of Texas.

Activity III. Educational Programs

1. Give an illustrated talk to your school or a local organization about the life histories and management of marine fish or shellfish. Choose species you think would be of the greatest interest to your audience. Include informa-

tion on how to identify them, how they are used by man and any special problems involved in their management.

2. Make a display for your school or county fair. Choose any topic involving the Texas Coast that particularly interests you. Some suggested topics include marine and shoreline food webs, fish and shellfish identification, life cycles, salinity ranges and distribution of organisms in estuaries, water movements (tides, waves, currents), seashell collections, and the value of the seafood industry to the Texas economy.

Other Reading Materials

Books

Fotheringham, N. and S. L. Brunenmeister. 1975. *Common Marine Invertebrates of the Northwestern Gulf Coast.* Houston: Gulf Publishing Company.

Herald, E. *Fishes of North America.* Animal Life of North America Series. New York: Doubleday & Company, Inc.

Hoese, H. D., R. H. Moore and F. Sonnier. 1977. *Fishes of the Gulf of Mexico: Texas, Louisiana and Adjacent Waters.* College Station, Texas: Texas A&M University Press.

Walls, J. G. 1975. *Fishes of the Northern Gulf of Mexico.* Neptune, New Jersey: Tropical Fish Hobbiest Publications, Inc.

Zim, H. S. and L. Ingle. 1955. *Seashores: A Golden Nature Guide.* New York: Golden Press.

Texas Agriculture Extension Service publications

MP-1000 Coastal Fisheries of Texas

MP-1009 The Estuarine Zone — Uses and Concerns

4-H Project Member Guide — Marine Ecology: Sea Shells from Port Arthur to Galveston Bay

Sea Grant College Program publications

Gallaway, B. J., J. C. Parker and D. Moore. 1972. *Key to the Estuarine and Marine Fishes of Texas,* second edition TAMU-SG-72-402. Sea Grant College Program and Texas Agricultural Extension Service, The Texas A&M University System.

TAMU-SG-72-515 Rigging and Gigging for Flounder

TAMU-SG-76-503 Sport Shrimp Trawling

Texas Parks and Wildlife Department publications

Bulletin 33 Food and Game Fishes of the Texas Coast

Bulletin 34 Crabs of Texas

Bulletin 50 The Shrimp Fishery in Texas

PWD Brochure 3000-3 Shark as Seafood

PWD Brochure 3000-6 Oysters in Texas

PWD Leaflet 2000-1 Digest of Shrimp Laws

PWD Leaflet 9000-5 Texas State Fish Records

Beezley, Clarence. "How to Build a Crab Trap"

Moffett, A. W. "Shrimp"

Simmons, E. G. "The Redfish in Texas"

Stevens, Jim. "The Speckled Trout in Texas"

"The Coastal Fisheries Program"